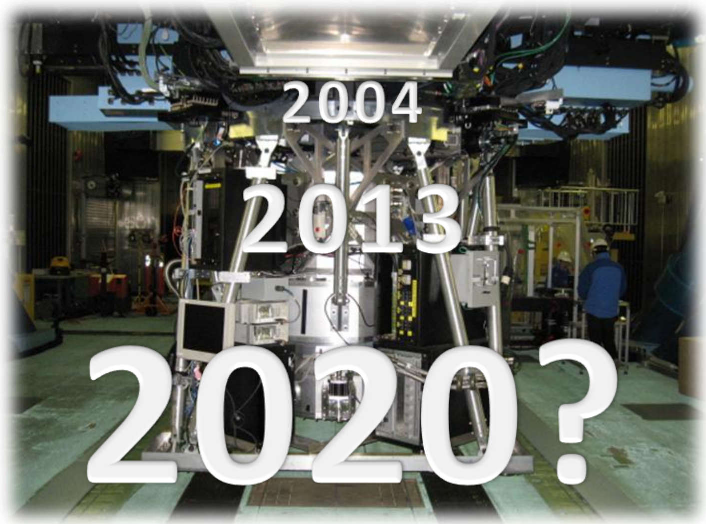
GLAO Instrument from MOIRCS Perspective



Ichi Tanaka

Subaru Telescope

Preface

Question:“How you want to use 8-m Telescope in 2020s when TMT/GMT/JWST/WISH etc are there?”

“Attractiveness” of the instrument itself is the key for success.

Attractive=Challenging (no counterpart). If overcome, great idea will follow (I believe).

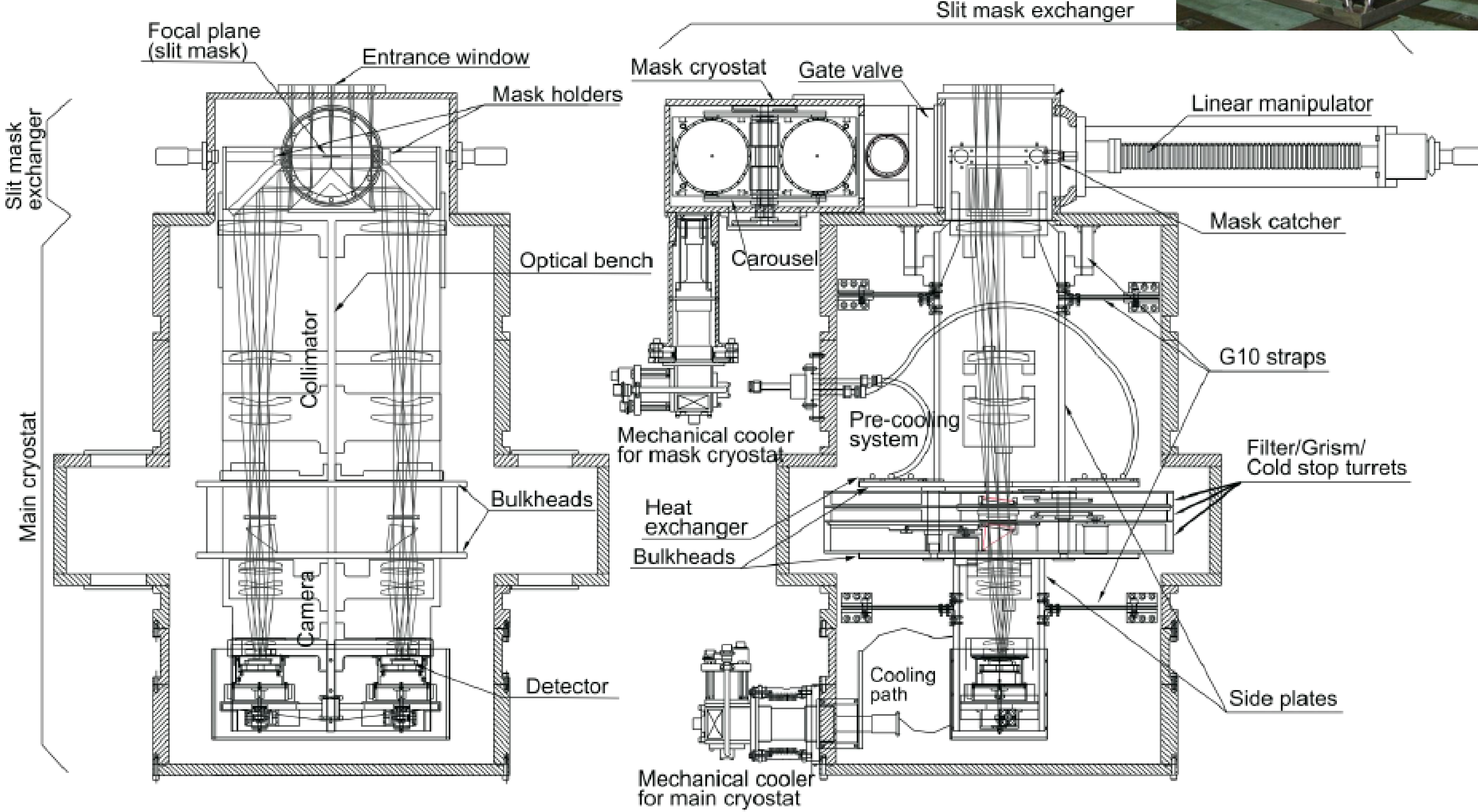
「人に使ってみたくさせる様な、魅力的な装置」をいかに(経済的に) 作るか。進化の可能性を維持する事ができるか。

MOIRCS

- FL … Sep 2004 (imag) & 2005 (MOS).
- Open-use started from S06A.
- The First NIR MOS open-use instrument among large telescopes.
- The First Wide-Area NIR instrument for large telescopes until arrival of HAWK-I

- Imaging: 4’x7’ FOV by 2 H2. YJHK & many NBs
- MOS/long slit. R500, R1300, VPH(YJHK).

MOIRCS



SIDE VIEW

FRONT VIEW

MOIRCS: Pros

- Cs instrument →Better background performance in K than Ns (cf. HAWK-I).
- 3 Filter/Grism/Stop Turrets (total 36 ports) → Many Filter Ports available for user filters & grisms.
- 0.117”/pix → Good sampling for good condition. ~3 pix condition is not so rare. → Good choice.
- 2 independent channel … Die Hard to trouble (half-channel operation possible).

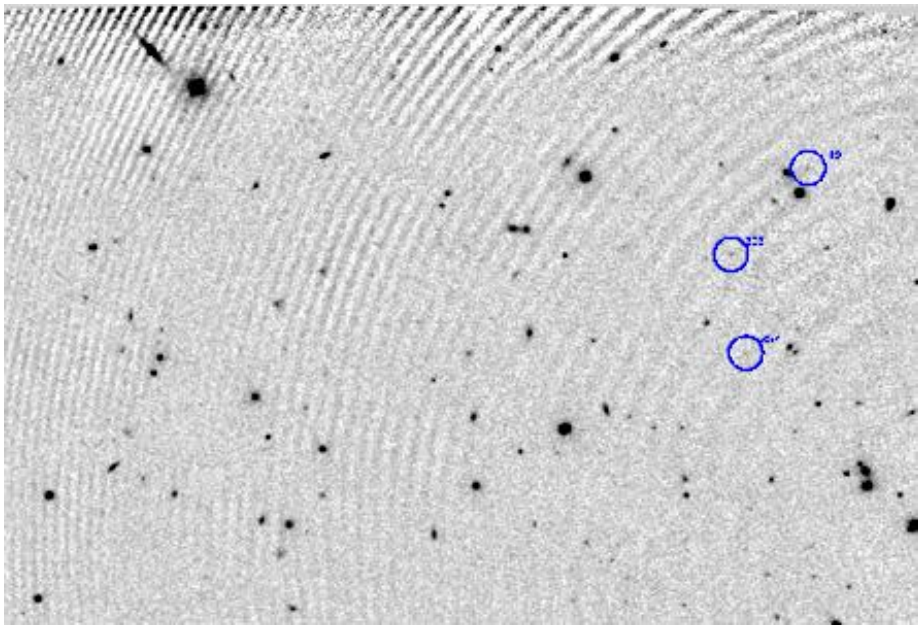
Complicated operation (e.g., ch1->sp, ch2->im) is also possible.

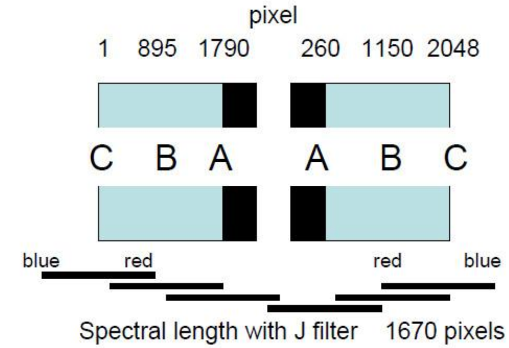
Dubbed by Kodama san

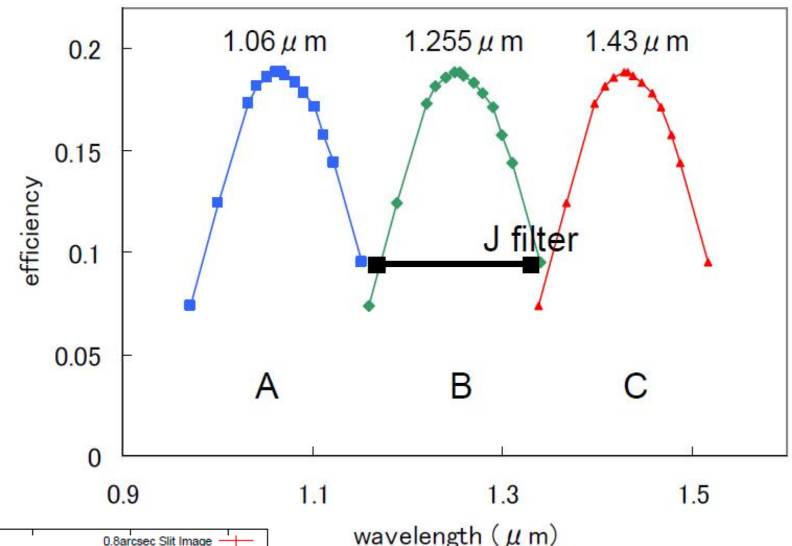
MOIRCS: Cons

- Flexure … Large line residual after sky subtraction (Sp.). Shift of the spectra. Fringe on imaging data.
- Poor Align of Cold Stop. No way to fine adjust.
- Large overheads: Too slow detector readout. Slow MOS alignment time.
- R500…too many OH lines. R1300…very low sensitivity for YJ. Image degration by grism itself. VPH…Peak efficiency wavelength shift: very difficult to use for MOS.
- Frequent focus change (telescope). AG does not help for check due to the focus mismatch.

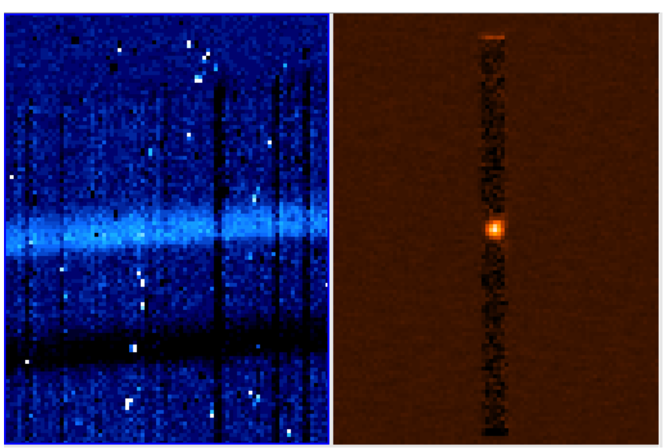
Fringe Residual (H2 filter)



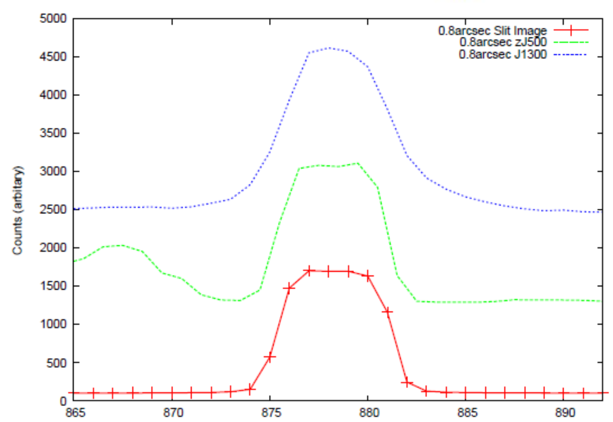




Peaky & Large Tc shift for VPH Grism

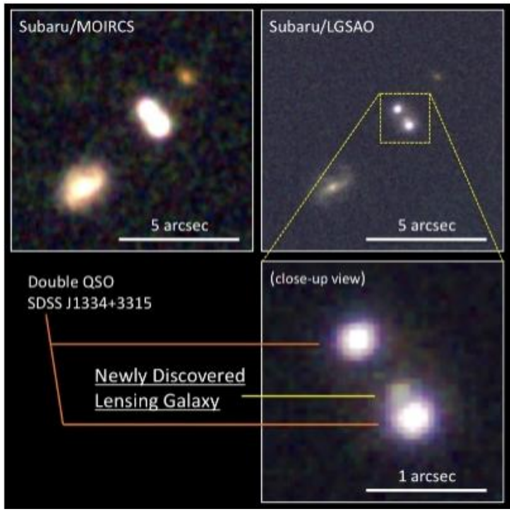


Degration for spatial direction



Degration for spatial direction (R1300)

MOIRCS: Scientifically…



- Good Imaging Performance. But studies for morphology are limited. Mostly just photometric use.
- Deep obs … condition averaged out -> degrade.
- Deep Imaging Data…follow-up impossible?

(But All visible objects will be spectroscopic targets for TMT !!)

- Many users went for field galaxy studies. → “Main” targets are not so rich in the MOIRCS FOV. Many are just filler objects. (cf. FMOS)
- Limit of photo-z and instrument sensitivity: >50% success rate for spec-z is a hard task (partly due to fillers).

- Spec data is quite sensitive to seeing under 0.8”-width slits. Slit loss is a serious issue.
  - Narrower slit is preferred to avoid OH lines.
  - But NOT all galaxies are compact enough to confidently use 0.2”-0.4” slits. Extended galaxies might also be morphologically complex.

  →Extragalactic People may choose wider slits after all (more photon is preferred)? e.g. 0.6” slit for 0.06”/pix => 10pix profile!

Cf.) oversampling problem on FOCAS (Dr.Ohyama’s review 2005).

Is simple MOS still attractive for 2020 era? But MOSFIRE type/microshutter technology may worth trying.

FOCAS進化論(FOCAS Instrument Review) by Dr. Y. Ohyama (2005)

- FOCAS: Subaru optical MOS Spectrograph.
- Dr. Ohyama --- 1st FOCAS SA.
- His Review --- Suggestive to NGAO Instrument.

想定外？(1)

撮像エリアと分光エリアが同一サイズ？

- DEMIOS: 2Kx4Kx4 for imag. 2Kx4Kx8
- VIMOS: 2Kx2Kx4 for imag, 2Kx4Kx4
- GMOS: 2Kx4.5Kx3 の中央部 for ima
  全域 for spec.
- FOCAS: 2Kx4Kx2 for imag, 2Kx4Kx2

✓ 分光領域を優先すると、6' fai の全域に天体を
ない事態が多数発生！
- MOS multiplexing gain 向上の足かせ。

想定外？(2)

分散、分解能 、CCDサイズ、Pixel サイズの悩ましい関係

- 0.2" slit がデフォルト？
  - 0.1" per pix のオプティマム・サンプリング
  - 0.2" ぐらいなら、たしかに結構な分解能になる。
- 実際は、0.8"-1.0" slit が多用された。
  - 微光天体の slit loss は避けたい。
- 一方、
  - サイエンス上、高めの分散を要求するものは多かった。
  - SDF などの MOS も、高めの分散の採用例が多い。
    - 75 グリズムで、スペクトルを縦にスタックする構想は、実現
- その結果、
  - 最大グリズム (VPH) でさえ、分散は不十分。
  - CCD を大量にビニング。
  - または、分散を優先して、フォトンを損。
  - 無理に高めのグリズムを使うと、波長帯域が減少。
  - MOS 時には、スリット位置に強い制限。
    - MOS multiplexing gain の足かせ。

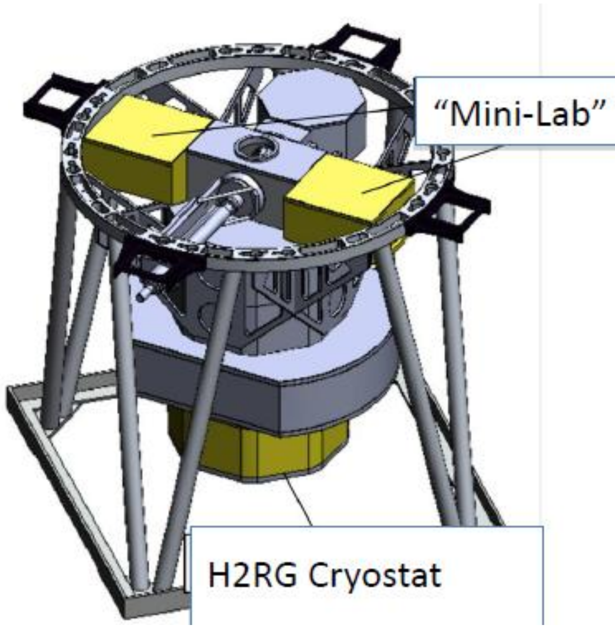
想定外？(3)

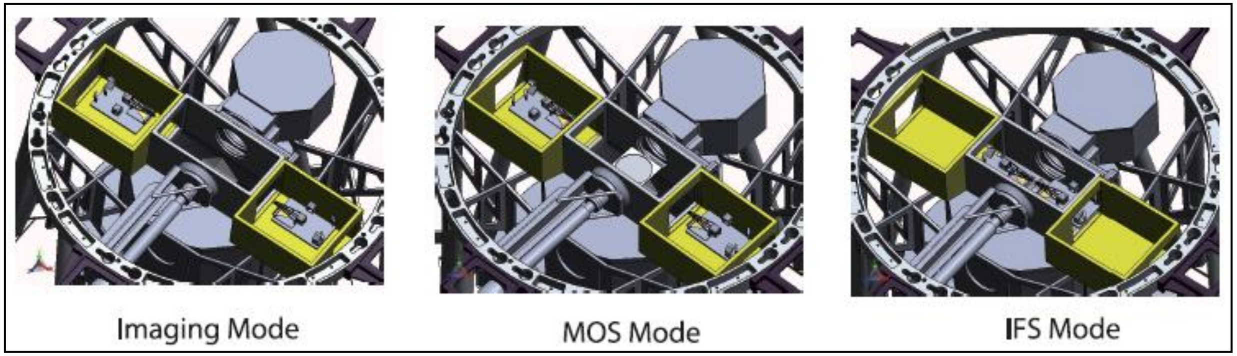
- FOCAS の flexure の設計要求は、<1 pix drift per 1h.
  - 十分な精度だったか?
    - 実際、精度は達成されていた。
    - ✓フリンジ除去、OH 夜光差し引きに問題！
      - 超微光天体検出能力をリミット。
- 世界の趨勢は、<1 pix drift per night.
  - Flexure compensation system (FCS) の活躍。
    - GMOS/ESI: open loop; DEIMOS: close loop
    - [VIMOS: extremely stiff structure]
  - Sky subtraction is KEY! Remove fringe!
    - 例えば、DEIMOS の PDR では、sky 差し引きの重要性がくどいほど強調されている。
    - 他分光器でも、程度の差はあれいずれも OH 引きに注意している。
  - 我々は、その重要性をどれだけ認識していたか?

http://optik2.mtk.nao.ac.jp/~cyoshida/SACsympo/

νMOIRCS: MOIRCS upgrade (2012~)

- **H2→H2RG+ASIC**: much better overhead & less cosmetics, good noise level expected.
- **IFUs**: 4 IFU arms will be added. Other options (MLA mode etc) are also on work.
- Instrument Improvement: Efforts for flexure suppression etc.

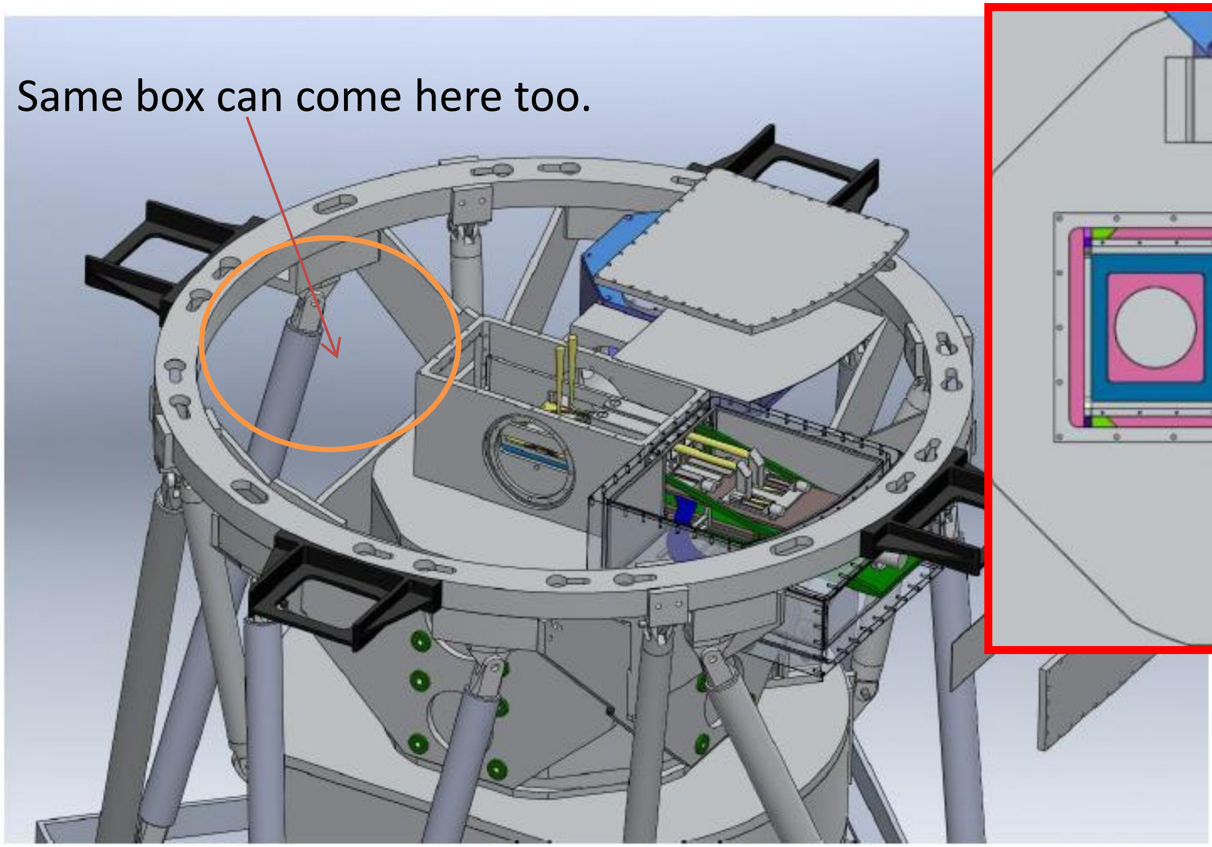


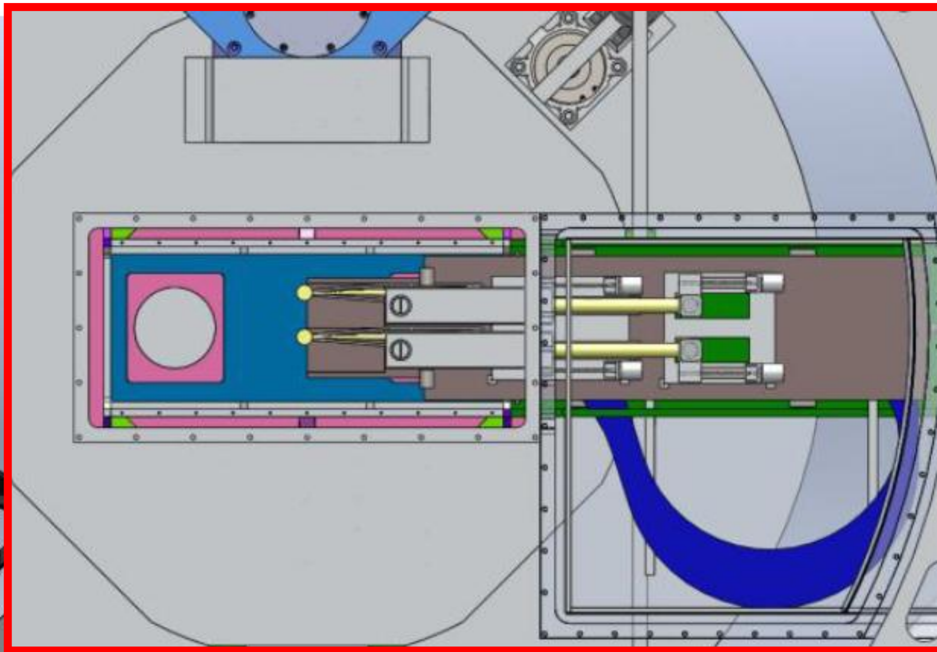


MOIRCS could be a 1st light GLAO instrument depending on the condition.

νMOIRCS "Wing Box"

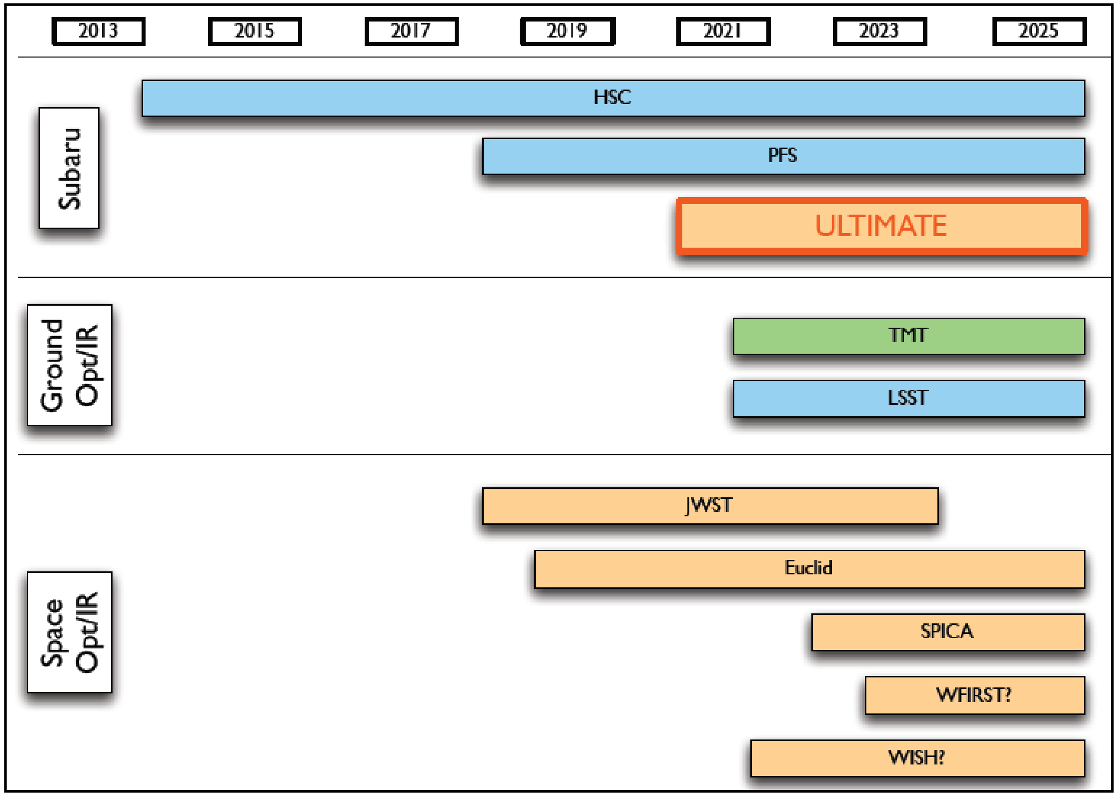
- Two wing boxes. 2 IFUs for each.
- If 4 IFUs are combined, it works as a large single IFU.
- Flexibility for Other Applications (test bench).
- <u>Modification: just replacement of Focal Plane Box.</u>





Great Idea for NGAO Instrument

NGAO Instrument and 2020

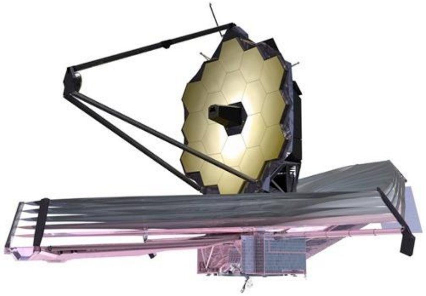


From Iwata report (2013)

- JWST, EUCLID (and I wish WISH too) will already be there.
- TMT comes soon. **GMT** may already be there (FL late 2019). E-ELT will be soon(early 2020s).
- TAO will be soon (SWIMS could also be a FL instr for GLAO).

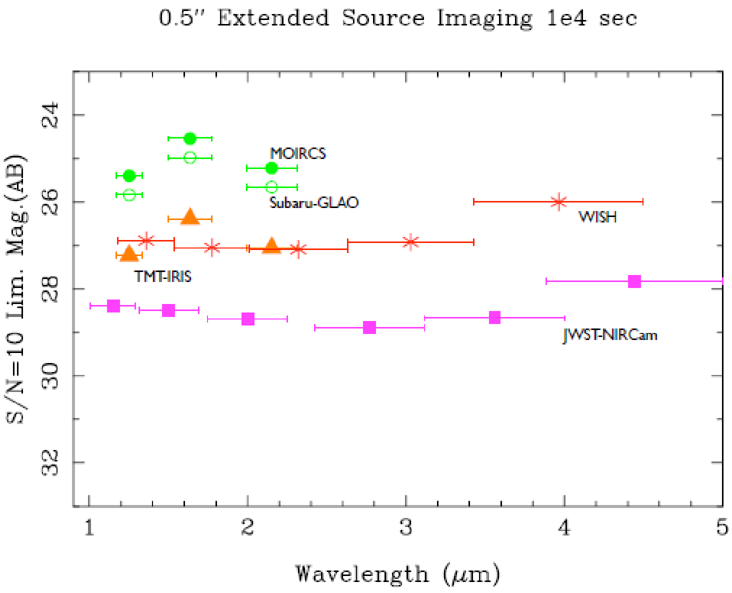
JWST (Imaging)

- NIRcam can go extreme depth.
- **Wide-area shllaow(still deep) scan should also be an easy task.**
- Pressure for COSMOS-Like Legacy Data →deg^2-scale survey likely to be executed. But 10^2 scale would be too time-consuming for JWST.



- Wide FOV of **NGAO Inst**. can make the data **with 10-100 sq.deg** with reasonable time. We may keep some niche, until WISH comes.
- Any NB deep & wide-area survey would keep its own niche until WFIRST comes (next).

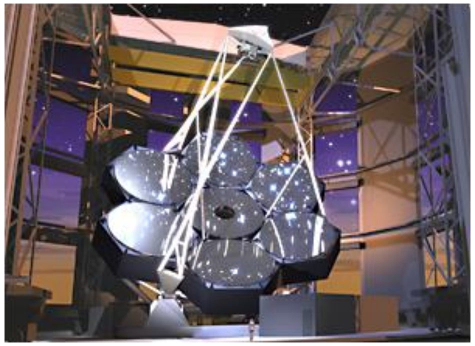
- **K-band wide and deep** would be attractive for EUCLID Deep Field (and WFIRST).



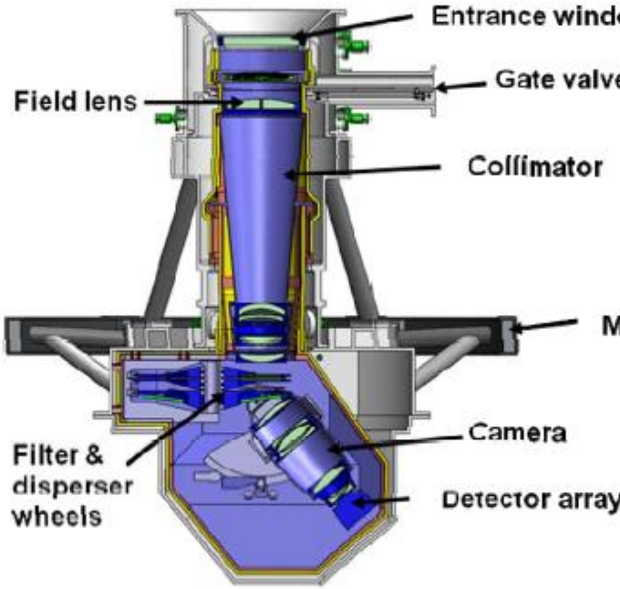
- **1st –ranked space mission by Decadal Survey 2010.**
- Significant revision in 2013: 1.3m → **2.4m.** Two Mirrors and optics system are already in NASA (given from NRO)!
- 18 H4RG. FOV=0.281 deg^2(0.11"/pix). 0.76-2.0um (**no K**).
- Slitless Grism (R~700)+ 3.0"x3.1" IFU(R~100).
- **Imaging (YJH~<26.7) and Spectroscopy (7s to $5e^{-17}$erg) for ~2000deg^2!**
- If started next year, Launch will be ~2022.
- **For GLAO Inst…only K-band (NB,BB) is the niche. Early start is advantage.**

GMT NIRMOS: Potential Threat?

- GMT … FL goal is **end of 2019**. Construction started, 2 mirrors already done (3rd in Aug?).
- NIRMOS … 1st generation propsed instrument. GLAO-assisted **6.5’x6.5’** NIR imager/**MOS** (CfA).
- 3x2 H4RG.



- MOS mask or MOS robot.



- CoDR review approved. Actively seeking funding.
- Filter space is currently quite limited.
- NGAO Instr….NB/IB only?

JWST: NIRISS

- Space … Power of slitless spectroscopy.
- JWST NIRISS: R~150 slitless spec. across ~2’x2’ FOV. Instrument is already in GSFC for test.
- Extreme sensitivity: best for faint z>7 LAEs.

- Narrow FOV? Survey volume of slitless spectroscopy is large (6<z<17). They will do Legacy-class survey anyway (deg^2)?.

- Subaru NGAO inst. may still have a niche in **targeted wide-FOV NB business**. For K-band region we have.

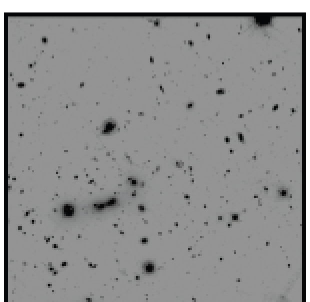
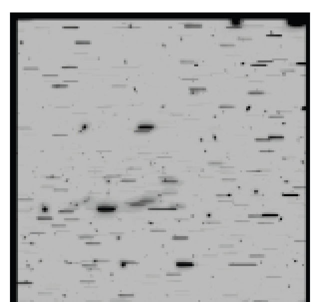
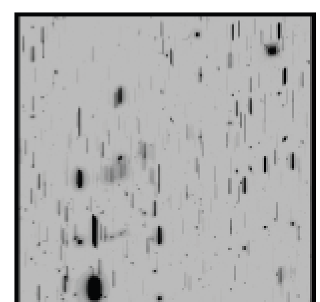


Image: F200W



Spectra: GR150R, F200W



Spectra: GR150C, F200W

What our NGAO Instrument would be…

- We want everything (Imaging, MOS, IFUs)!
- But budget is limited. Weight limitation is also tight.

nuMOIRCS Approach might be a solution…

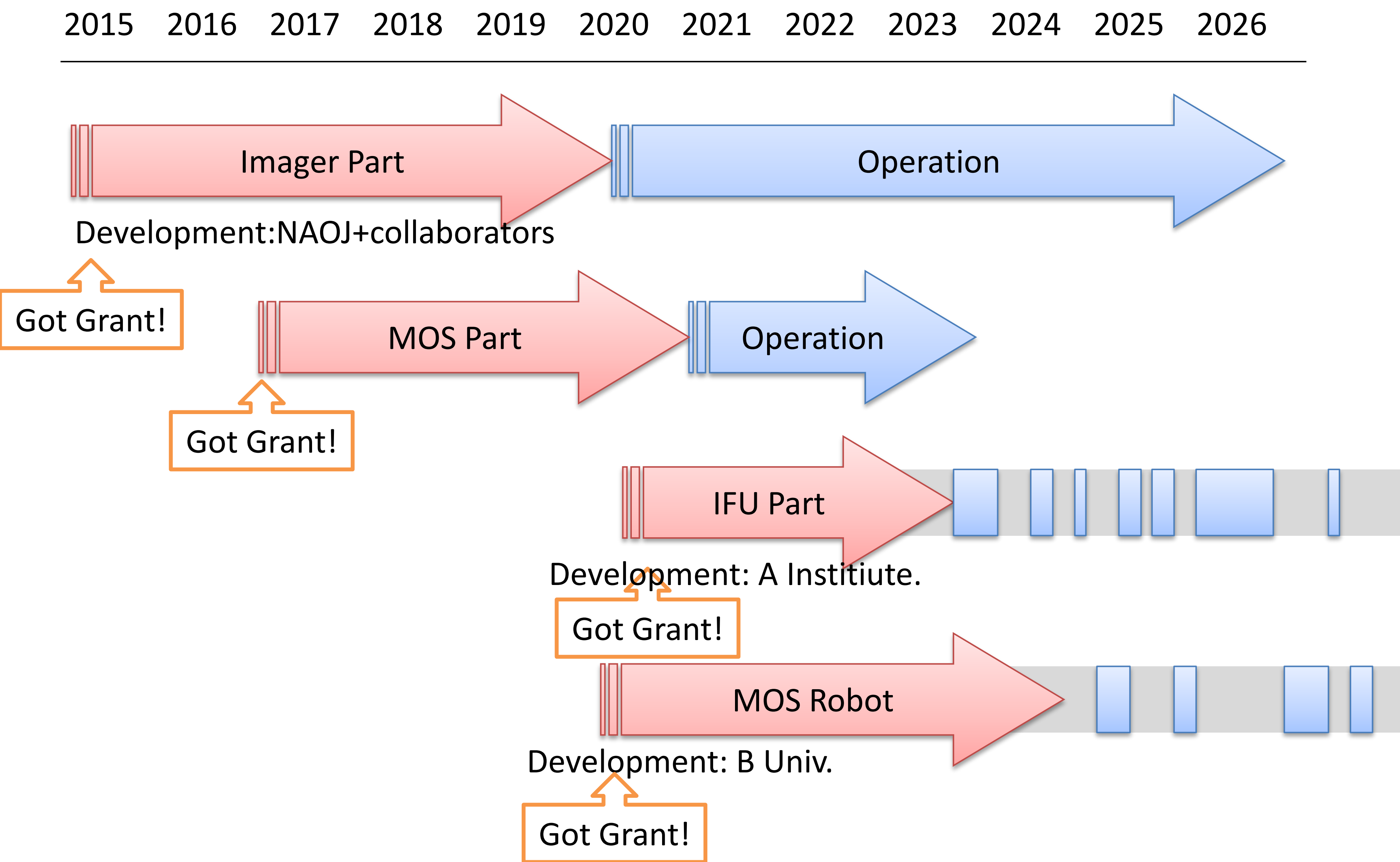
“NuMOIRCS” approach … great idea.

1. Making Imager First.
   - High Throughput. Simple Design.
   - Wide Fov, optimized to K band.
   - **The Design for future addition of spec. function (=MOS/IFU etc) must already taken into account.**

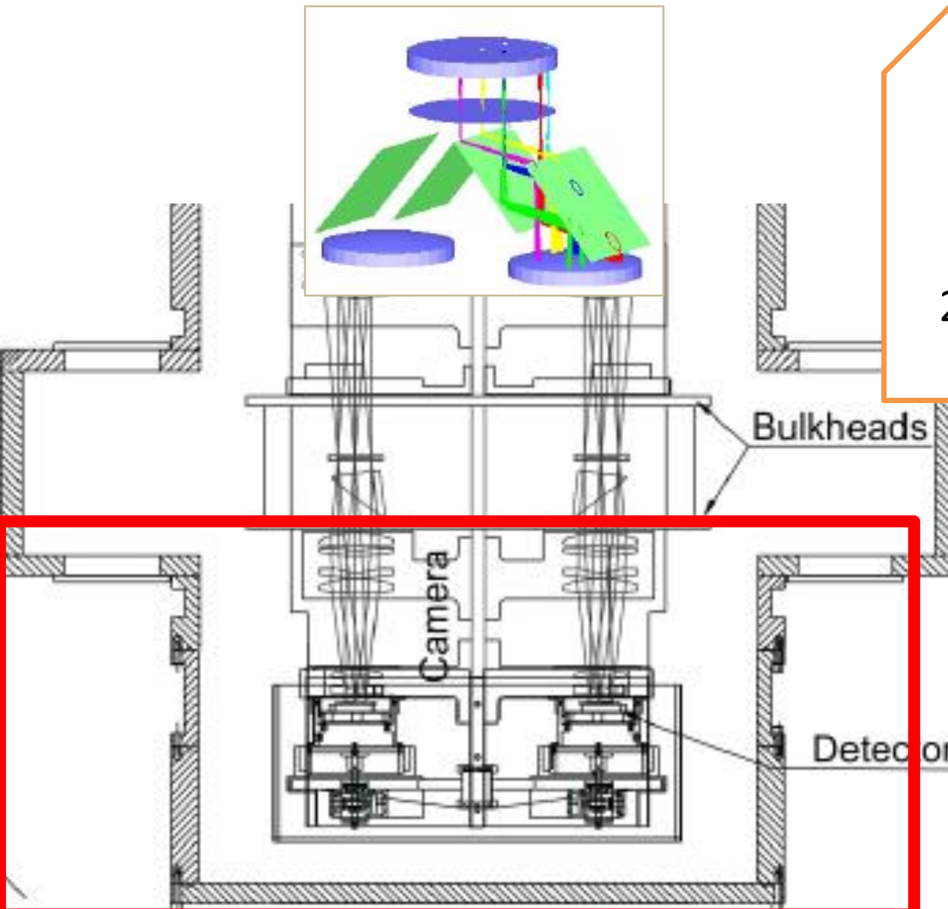
2. **Making Unitized** Additional Components
   - MOS Robot Unit (MOSFIRE-type)?
   - IFU(s)
   - Near-Focal Plane NB Filters w/stacker?
   - Is High Throughput “Giant” NIR-FP possible?
   - Easy Convertibility --- they should be detachable with small downtime (~1 mo).

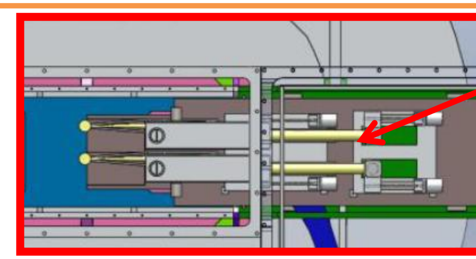
Unitization has advantage on risk/cost/manpower management.

Example of development case…



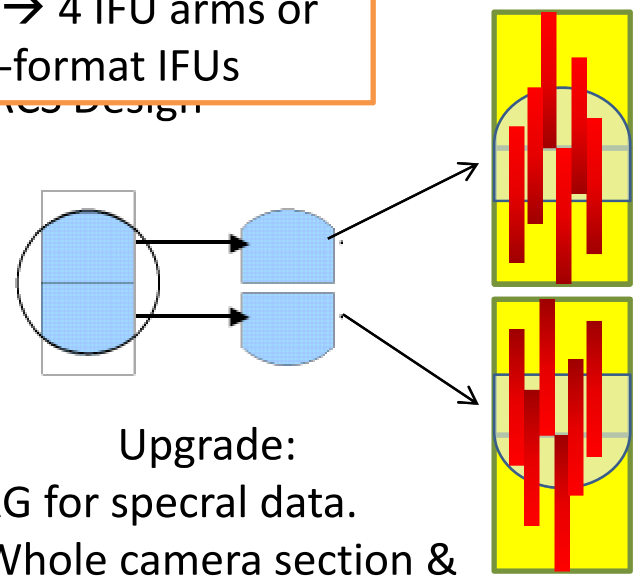
Option 0':"Cheapest" IFU option?
A Further MOIRCS Update Project





Change to more smart IFU arms? Larger IFU pick?

2 IFUs arms → 4 IFU arms or
2 Larger-format IFUs



Upgrade:
2 more H2RG for specral data.
Change of Whole camera section & bottom dewar part.
1.Afford more IFU spaxel.

Project: "νMOIRCS" → "F_ν MOIRCS?"

Summary

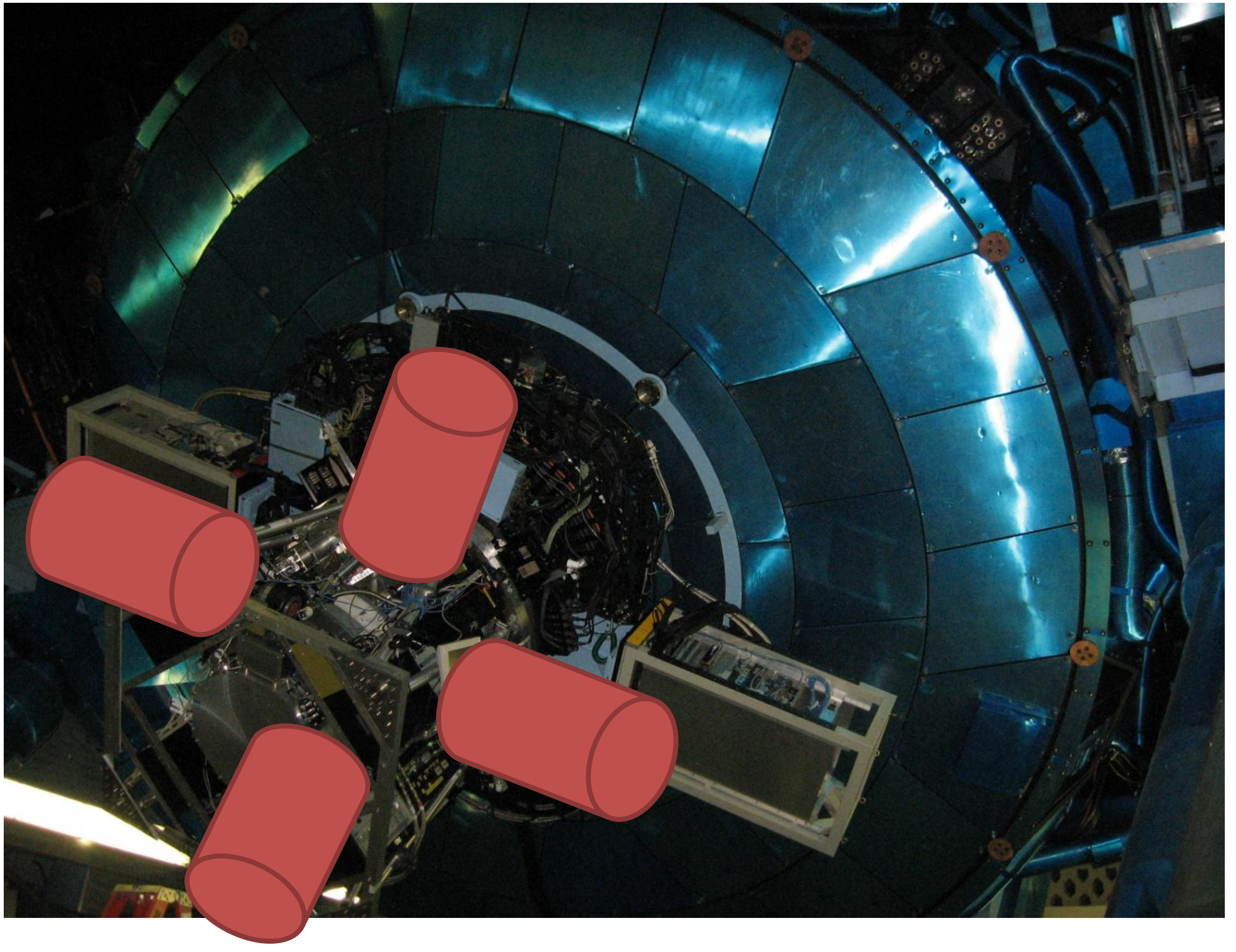
- NGAO Instrument … Starting from Imager may be a realistic option.
- Unitized Design for further update (νMOIRCS-like approach) could be the solution for collaboration and difficult budget situation.
- FνMOIRCS? Good timing for it? As SWIMS comes to Subaru as a guest instrument.

(For me) manpower appears potentially the most serious issue for the project. How the project is going for realization??

Omake Idea…

(Based on a word from Y.Tanaka)

If 2-m limit causes more number of lenses, degraded pupil,etc…
Let’s seriously think about using whole bottom of telescope.



Ligntweight design of the dewar is also the key! Honeycomb-like wall?